COMPOST FROM MARKET GARBAGE USING LOCALLY ACCLIMATIZED ORGANISMS.

H.M.M. Herath ¹, S. Pathinather ¹, S. C. Wijayarathne ²

¹ Dept. of Civil Engineering, Faculty of Engineering, University of Moratuwa
² Dept. of Botany, Faculty of Applied Sciences, University of Sri Jayawardenapura.
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H.M.M. Herath, 1 S. Pathinather, 1 S. C. Wijayaratne 2
1 Dept. of Civil Engineering, Faculty of Engineering, University of Moratuwa
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ABSTRACT

Nearly 80% of Sri Lankan garbage is biodegradable organic material. Today organic wastes are increasingly being converted into compost. Therefore it is necessary to look into the possibilities of improving compost quality and reducing the time taken for producing stable compost. This study was conducted using market garbage as the major ingredient of the composting process. The objective of this study is to reduce the production time of compost with the use of inoculants and aeration. Vegetable garbage, air-dried grass clippings, saw dust, cow dung & coir dust were used as the raw organic materials. The windrow method was used to prepare compost under indoor environmental conditions. A hollow triangular wooden frame was used in the pile to facilitate aeration. Mature compost was used as the inoculant to accelerate the composting process. The initial total weight of garbage was 250 Kg and after two months became 125 Kg. During the composting period compost pile was mixed once a week and the samples were tested in the laboratory. Physical & chemical changes of composting process were studied to evaluate the increasing efficiency due to inoculation & aeration. The periodic changes of temperature, pH, percentage of organic matter, carbon dioxide production rate, bulk density, weed seed germination were monitored during the composting process. The C/N ratio was measured to evaluate the degree of maturity of the compost. After two months of composting process, presence of pathogenic organisms (coli forms & ascaris egg mortality) and the maturity of the compost were determined. The study conducted up to now indicates that this process will give considerable information, which will help to reduce the environmental problem otherwise created by this market garbage.

INTRODUCTION

Market garbage is one of the major constituents of the municipal solid waste. It has a low calorific value and high moisture content and nutrients. In Sri Lanka, there is no proper management process to dispose of these wastes. This has led to many problems such as spreading of diseases, contamination of the air, water and ground and destruction of natural beauty.
By using this waste for composting it is possible to decrease the volume of waste, eliminate disposal costs and reduce the quantity of waste going to landfill. It will provide an additional source of income and good nutrients to fertilize plant growth. Composting is an aerobic oxidation process; raw organic materials are converted into a stabilized product by means of biological activity under controlled conditions. Under natural conditions the composting of organic materials takes a considerable time period. Therefore it is very important to find out appropriate technologies to increase the speed of composting process and improve the quality of the compost produced.

When developing the technologies for the process of composting, it is important to pay attention to physical, chemical and biological characteristics that are brought about by micro and macro organisms. The main objective of this research work was to evaluate the effectiveness of compost prepared from market garbage and to reduce the time of composting by inoculation and aeration.

MATERIALS & METHODS

Raw Materials Used for Composting

<table>
<thead>
<tr>
<th>Raw Material</th>
<th>Mixture I</th>
<th>Percentage (By weight)</th>
<th>Mixture II</th>
<th>Percentage (By weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market garbage</td>
<td>80%</td>
<td>Raw Material</td>
<td>Market garbage</td>
<td>50%</td>
</tr>
<tr>
<td>Coir dust</td>
<td>5%</td>
<td>Coir dust</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Saw dust</td>
<td>5%</td>
<td>Saw dust</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Cow dung</td>
<td>10%</td>
<td>Air dried grass clippings</td>
<td>25%</td>
<td></td>
</tr>
</tbody>
</table>

Table I

Experimental Site

This investigation was conducted at Kottawa composting site, inside a shed, which had a permanent roof with no surrounding walls.

Treatments and Experimental Design

- \( T_1 \): Used Mixture I (without bulking agent)
- \( T_2 \): Used Mixture II (with bulking agent)
- \( T_3 \): Used Mixture II (with bulking agent & 2.5% mature compost)

There were two replicates for \( T_1 \) and \( T_3 \) treatments and three replicates for \( T_2 \) treatment.
Procedure Adopted in Making Compost

The composting of organic materials was carried out aerobically using windrow method under indoor environmental conditions. The aeration of composting pile was facilitated with a wooden triangular hollow frame (Figure I).

Figure I  Wooden Triangular Hollow Frame

The experimental unit was 1.5 m x 1.5 m x 1.0 m (width x length x height). All the components taken in the above ratio were well mixed before use. Water was sprinkled over the raw materials to get moisture content of about 60%. For T3 treatment 2.5% mature compost (by weight) was added. Finally the heap was covered with polysac bags. During the experimental period the pile was turned once a week to facilitate aeration.

Sampling Procedure

Samples for chemical analysis were taken at the time of mixing of the pile. Prior to chemical analysis the samples were stored in black polythene bags at 4 °C.

Temperature

Monitored daily at three depths (top, middle and bottom) from the center between 10 a.m. - 12 noon with a temperature probe. The ambient air temperature was also measured.

Bulk Density

The fresh compost was packed into a graduated container, without air spaces, then the weight of sample was taken. This was divided by the volume of the container to get the bulk density (Cornell Composting Science and Engineering, http://www.cals.Cornell.edu, 2000).
Changes in the Distribution of Particle Size
Mechanical sieve shaker was used, with 5 mm, 2 mm, 1 mm, 0.5 mm, 0.25 mm equipped with cover and bottom pad. Thoroughly mixed 50 g air-dried compost samples were sieved at a constant speed for 5 minutes.

Percentage of Organic Matter
The oven-dried samples were placed in crucibles of known mass. The samples were ignited in a muffle furnace for half an hour at 700 °C.

Reduction of Volume and Weight
The pile volume was measured at the end of every week. Then the final weight was measured after 2 months of composting process.

Viability of Weed Seed Germination Affected by Composting Process
20 seeds of *Amaranthus* sp were placed in nylon bags and buried at 20 cm, 40 cm, 60 cm within the compost pile. They were treated 3, 7 and 10 days in the compost pile and their germination ability were checked.

Invertebrates
Observed different types of invertebrates, which appeared at different stages of composting.

pH
Measured soon after the sampling. A suspension of 5 g of sample in 50 ml of deionized water was made and kept the suspension for 1/2 hour with occasional stirring. The pH was determined using a pH meter.

Carbon dioxide Production
Air was extracted from compost pile through a glass funnel, which was firmly embedded in the compost pile, by means of a pump at a constant rate. The air was allowed to pass through 0.25 N NaOH solution (500 ml) for a period of one hour.

Total Nitrogen
Determined by Macro Kjeldhal method.

Organic Carbon
Determined by Walkey & Black method.

Presence of Human Intestinal Parasites
Detected by using microscope.

Presence of Coliform
Multiple fermentation tube test was carried out using $10^{-4}$ dilution and MacConkey broth.

Maturity of compost
Seeds of *Raphanus sativus* were used.
RESULTS AND DISCUSSION

Temperature

Figure II

Variation of Temperature with Time

Figure III

Temperature variation in compost pile T1

Figure IV

Temperature variation in the compost pile T2

Figure V

Temperature variation in compost pile T3

At the initial stage the temperature of the three treatments increased and then gradually decreased with time. The highest temperature was recorded within 2 days after starting decomposition. During the first week the temperature of T2 & T3 treatments remained at or above 40°C.

The lowest temperatures were recorded from T1 treatment at the early stage. Figure II shows the increase of temperature, which followed each turning operation of the pile carried out once in seven days. After 5 weeks the
temperature dropped and did not produce significant rise in temperature above the ambient temperature.

According to figures III, IV, & V there was a temperature gradient inside the pile. Highest temperatures were recorded at the middle of the pile. The temperature at any point depends primarily on the amount of heat generated by activity of microorganisms and the amount lost through aeration & surface cooling. Initially the temperature builds up, and then it declines due to depletion of organic materials caused by the rapid decomposition. The chemical composition of the ingredients, moisture content as well as the shape & the size of the compost pile, determine the duration in which higher temperature is maintained. T₁ showed the highest temperatures during the initial stage and this may be due to the inoculation of the pile with mature compost. For best results the temperature should be maintained at 55°C –60°C and when it exceeds 60°C the biological reaction slowdown and heat may be released by turning the pile (Sincero and Sincero, 1996).

Turning the compost caused replenishment of the O₂ supply and exposure of new surface to decomposition and this caused a drop and then the temperature started to rise as indicated in Fig II.

Changes in the Distribution of Particle Sizes

![Graphs showing changes in the distribution of particle sizes over time](image)

**Figure VI**

**Figure VII**

**Figure VIII**

**Figure XI**
According to figure VI, VII, VIII, IX, X & XI changes in the distribution of sizes of compost particles progressed at a considerable rate throughout the composting process. Over the composting process the proportion of particles greater than 5mm decreased in T2 & T3. The materials less than 5mm in diameter appeared more active in the composting process. Figure VI shows that T3 treatment had promoted rapid change of particle size than the T2 treatment. The result demonstrates the physical breakdown of organic matter by micro and macro organisms. The particle size of composting materials should be as small as possible so as to allow for efficient aeration and to be easily decomposed by the bacteria fungi and actinomycetes (Polprasert, 1989). Where as the optimum size varies from 20mm to 75mm according Sincero and Sincero, 1996. The larger particles are important in providing aeration during decomposition.

**Bulk Density**

According to the Figure XII (T2 & T3 treatments), the bulk density of composting organic materials increased as it decomposed. This rate was slightly higher at the T3 treatment. Microorganisms degrade carbon-contained materials and respired it as CO2. Individual particles of organic matter lose the weight as they are decomposed. As recorded by the sieve analysis the proportion of smaller particles increased over the time. As the particles are
broken down physically the total pore spaces of composting pile decreased over the time then the bulk density of composting organic materials increased.

**The Reduction of Volume and Weight**

![Graph showing percentage of volume reduction over time](image)

**Figure XIII**

**Weight Reduction with Time**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Weight After 2 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2</td>
<td>130Kg</td>
</tr>
<tr>
<td>T3</td>
<td>120Kg</td>
</tr>
</tbody>
</table>

**Table II**

At the end of 2 months, the reduction of volume and weight was approximately same in both T2 & T3 treatments. Under controlled conditions of composting the volume reduced by less than 1/3 of its initial volume and the final weight was approximately half of the original weight.

**Viability of the Weed Seeds**

<table>
<thead>
<tr>
<th>Treatment period</th>
<th>Germination %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Depth</td>
</tr>
<tr>
<td>3 days</td>
<td>Top</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
</tr>
<tr>
<td></td>
<td>Bottom</td>
</tr>
<tr>
<td>7 days</td>
<td>Top</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
</tr>
<tr>
<td></td>
<td>Bottom</td>
</tr>
<tr>
<td>10 days</td>
<td>Top</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
</tr>
<tr>
<td></td>
<td>Bottom</td>
</tr>
</tbody>
</table>

**Table III**

* Seed coat cracked but sprouting was not observed. Therefore no germination. There was no significant difference between the two treatments (T2 & T3) Destruction of weed seed takes place when they are exposed to high
temperature (>60°C) for about 3 days. Viability of weed seeds was checked at places where the temperature was 60°C up to three days. This caused the seeds to lose their germinating ability.

**Compost Invertebrates**

During the composting process centipedes (brown & black), millipedes (red & black) sow bugs, earwigs, spiders and ants were observed in two treatments (T2&T3).

**Carbon dioxide Production**

![Graph showing carbon dioxide production over time](image)

**Figure XIV**

According to the figure XIV (T2 & T3), the highest rate of CO₂ evolution was reported in the 1st week. But T2 had lower values than the T3. In both treatments the rate of evolution of CO₂ decreased at the final stage of decomposition. Carbon dioxide production curve during composting follows the same pattern as the temperature curve. When the temperature is high the level of decomposition is also very high (Lubke, 1995).

**pH**

![Graph showing pH changes over time](image)

**Figure XV**

The initial pH of the compost mixture was 8.1. In T3, the pH value exceeded 9.0 during the 1st week. The pH of T2 treatment increased until 4th week but did not reach high values and then gradually decreased. In both cases decomposition has occurred under alkaline conditions.
The production of carbon dioxide and pH change varies with time during the composting process and is a good indication of the extent of organic matter decomposition. Mineralization of organic matter leads to temperature increase and thermophilic microorganisms become activated. They produced more CO₂, H₂O and heat, as byproducts of rapid decomposition. According to figure XIV CO₂ production rate was higher at the initial stage of composting.

When the pH goes above 8.5, more N₂ will be lost, which can upset the C/N ratio (Sincero and Sincero, 1996). When composting was in progress the organic materials tend to get compacted and as a result porosity decreased. This leads to depletion of O₂ in the pile, which in turn decreased pH values and CO₂ evolution rate, after the initial high temperature period.

**Percentage Organic Matter**

![Percentage of Organic Matter](image)

*Figure XVI*

According to figure XVI in both T₂ & T₃ the percentage of organic matter decreased. The rate of decrease was higher at the initial high temperature stage.

**Total Nitrogen Percentage**

![Changes in Total Nitrogen with Time](image)

*Figure XVII*

As figure XVII demonstrates, in T₂ & T₃ treatments during the composting process the percentage of Total Nitrogen increased. But there was a
considerable fluctuation. After 2 months T1 had the highest percentage value. However, this fluctuated considerably in both treatments.

**Changes in C/N Ratio**

![Graph showing changes in C/N ratio with time](image)

*Figure XVIII*

Figure XVIII shows that the C/N ratio decreased during composting. In both treatments, the rate of decrease was higher at the initial stage. There are many parameters used to judge the maturity of a composting process, such as C/N ratio, cation exchange capacity, and molecular weight distributions of extracts from compost, which determine the degree of maturity. By measuring both degree of decay as a physical change and alkaline soluble lignin as a chemical change could also be used to measure maturity (Fujio et al, 1986). In both, after two months C/N ratio reached 10. During decomposition, the C/N ratio of organic materials tends to decrease with time. This results from the gaseous loss of carbon, while the nitrogen remains more tightly bound to organic matter. Therefore, the percentages of N in the residual substances continuously increase and percentage of organic carbon decreases as composting progresses. Since compost is used mainly to increase and maintain the soil organic matter, an appropriate C/N ratio would be between 20:1 to 10:1 (Alexander M, 1965). The final product obtained from T2 and T3 satisfies the requirement for the soil application as indicated earlier.

**Final Quality**

**Presence of Coliform**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>MPN results</th>
<th>Number/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial raw materials</td>
<td>3:3:3</td>
<td>+1100×10³</td>
</tr>
<tr>
<td>T2 (after two months)</td>
<td>3:0:0</td>
<td>23×10³</td>
</tr>
<tr>
<td>T3 (After two months)</td>
<td>1:0:0</td>
<td>4×10³</td>
</tr>
</tbody>
</table>

*Table IV*

There were coliform in the raw materials. But after composting process the number decreased in both treatments (T2&T3).
During composting in both treatments the temperature rose up to 60°C and remained at that level for one week and it was sufficient to destroy the total coliform to an undetectable level. Absence of coliforms in the final product makes it desirable and acceptable to the potential users.

**Presence of Human Intestinal Parasites (Ascarid egg Mortality)**

<table>
<thead>
<tr>
<th>Stage</th>
<th>T2 Treatment</th>
<th>T3 Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Compost Mixture</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>After Composting (2 months)</td>
<td>Absent</td>
<td>Absent</td>
</tr>
</tbody>
</table>

*Table V*

There was no contamination of the initial compost mixture with human feaces.

**Maturity of the Compost**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Seed germination %</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₂ (after 1 ½ month)</td>
<td>60%</td>
</tr>
<tr>
<td>T₃ (after 1 ½ month)</td>
<td>70%</td>
</tr>
<tr>
<td>T₂ (after 2 month)</td>
<td>100%</td>
</tr>
<tr>
<td>T₃ (after 2 month)</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Table VI*

Maturity indicates the degree or level of completeness of composting. For compost to be used on vegetation, the degree of maturity is important. If immature compost is used, plants can be damaged due to the presence of phytotoxic substances (Johansson et al, 1997). Immature compost may contain high amounts of free ammonia, certain organic acids and water-soluble compounds, which can be harmful to plant growth and cause odor problems. This bioassay indicated, that after 2 months the compost obtained from T₂ & T₃ treatments did not show any adverse effect on plant growth. Time taken to reach maturity depends on several factors including size of pile, frequency of turning and the materials used for composting. According to Tchobanoglous et al (1993) a medium size pile, turned weekly, matured in 4 to 6 months.

**T1 Treatment**

When only vegetables are decomposed the pile becomes compact. This resulted in poor porosity and O₂ depletion in the pile. Then the temperature of the pile did not rise. The problem in T1 treatment was the presence of large number of house fly larvae, which multiplied at the curing stage of composting. This was because, the temperature in T1 treatment did not remain at a temperature more than 50°C for 10 days. It takes 10-11 days to complete the life cycle of the housefly. They can't survive at temperatures higher than 55°C (Rynk, 1992). When a bulking agent is added porosity is increased and as a result high temperature is attained inside the pile due to the activity of
microorganisms. This causes the destruction of eggs of the housefly and also other pathogenic microorganisms.

CONCLUSION

Control of the composting process can shorten the period required for decomposition and stabilization of the organic waste and can produce high quality final product. When composting organic wastes such as market garbage under the tropical environmental conditions smaller piles & frequent turning are needed.

When the composting process is properly operated and maintained, under optimum conditions the final product can be obtained in eight weeks. When heaps are covered completely, will help to retain temperature of pile as well as to minimize the water evaporation and ammonia volatilization. The high temperature attained in the compost pile destroys pathogenic microorganisms, pests and weeds that are associated with raw materials.

For composting organic materials having high moisture content, addition of bulking agent is essential. Mature compost has a great diversity of beneficial bacteria, fungi actinomycete. When mature compost is used as an inoculum. It will provide all the required microorganisms to start decomposition quickly. Addition of mature compost accelerate the composting process and slows down the lag phase.

ACKNOWLEDGEMENT

Authors would like to extend their gratitude to the Asian Development Bank (ADB) for providing financial aid and the Universities of Moratuwa and Sri Jayawardenapura for all facilities provided for this project.

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